World Bamboo Conference 2024

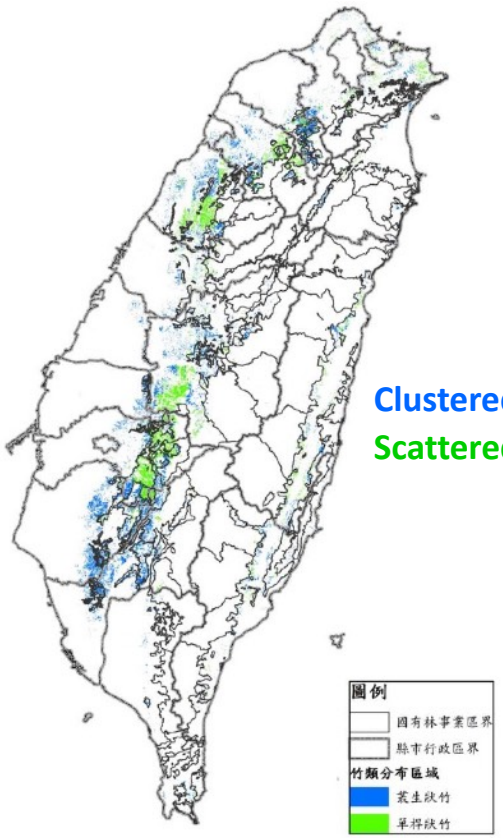
Effect of thinning on generation of bamboo forest in Taiwan

2024. 4. 19

Dar-Hsiung Wang, Tsai-Huei Chen & Hung-Chih Lin*

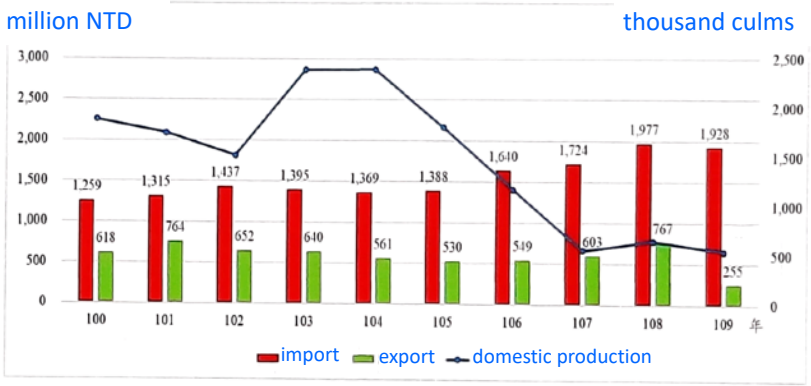
Taiwan Forestry Research Institute, Taiwan, ROC

Background



Clustered bamboos

Scattered bamboos



100-109年國產竹材生產量與竹材進出口趨勢圖

- pure makino bamboo forests (*Phyllostachys makinoi*) more than 40,000 ha in Taiwan
- mostly harvested by clear-cutting, and harvested again after 7-8 yrs
- because of conservation policy and increasing costs, production decreased after 2015
- abolished makino stands become aging and weak

Questions asked in this research

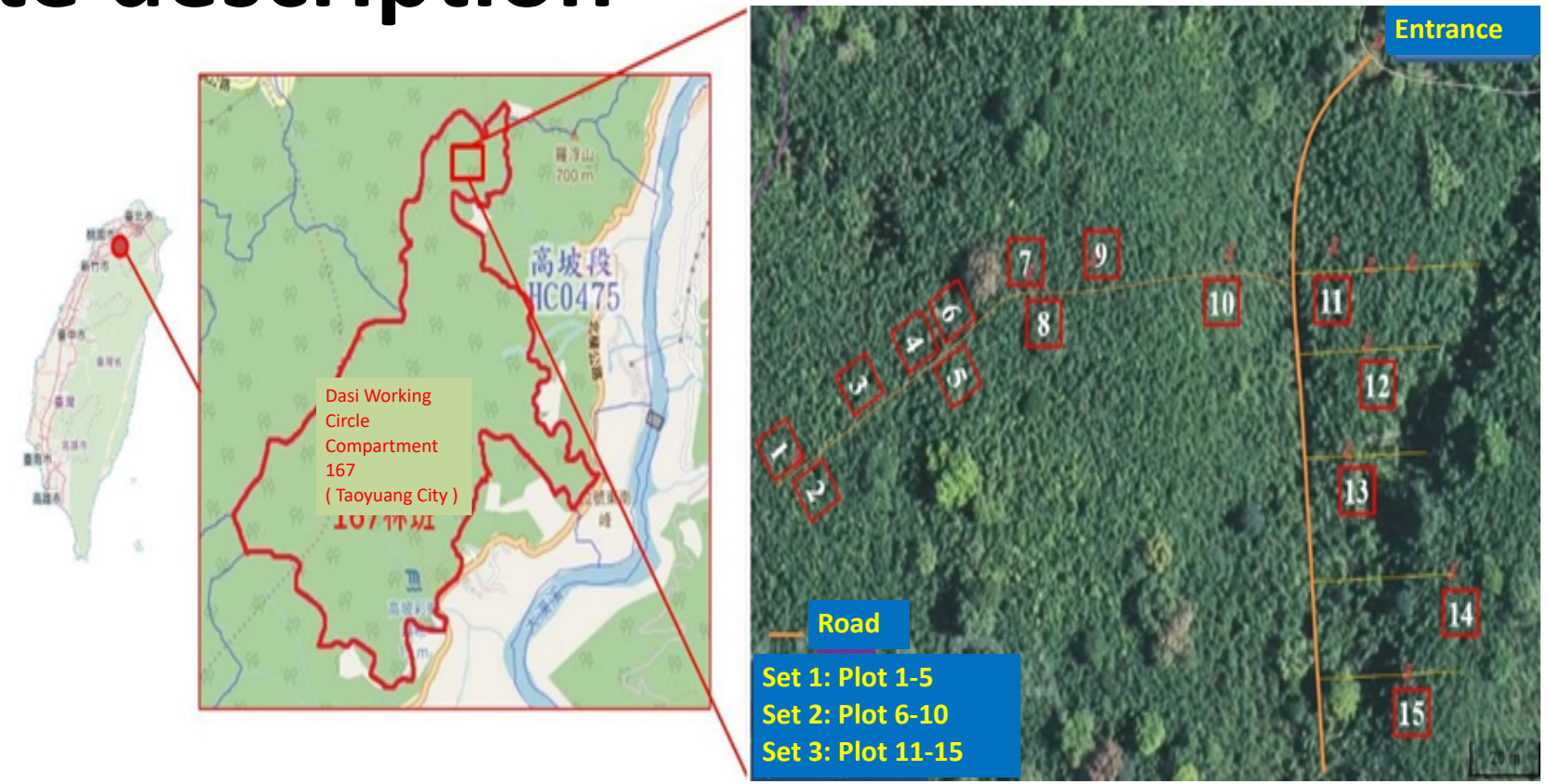
unmanaged and abolished makino bamboo stand

1. Does it need to do thinning operation for the abolished makino bamboo forest ?
2. What is the optimal level for the residual stand density after thinning ?
3. What is the years of thinning cycle for the sustainable bamboo management and utilization ?

Purpose of study

- Investigate the effects of different thinning intensity on the regeneration of makino bamboo forest.

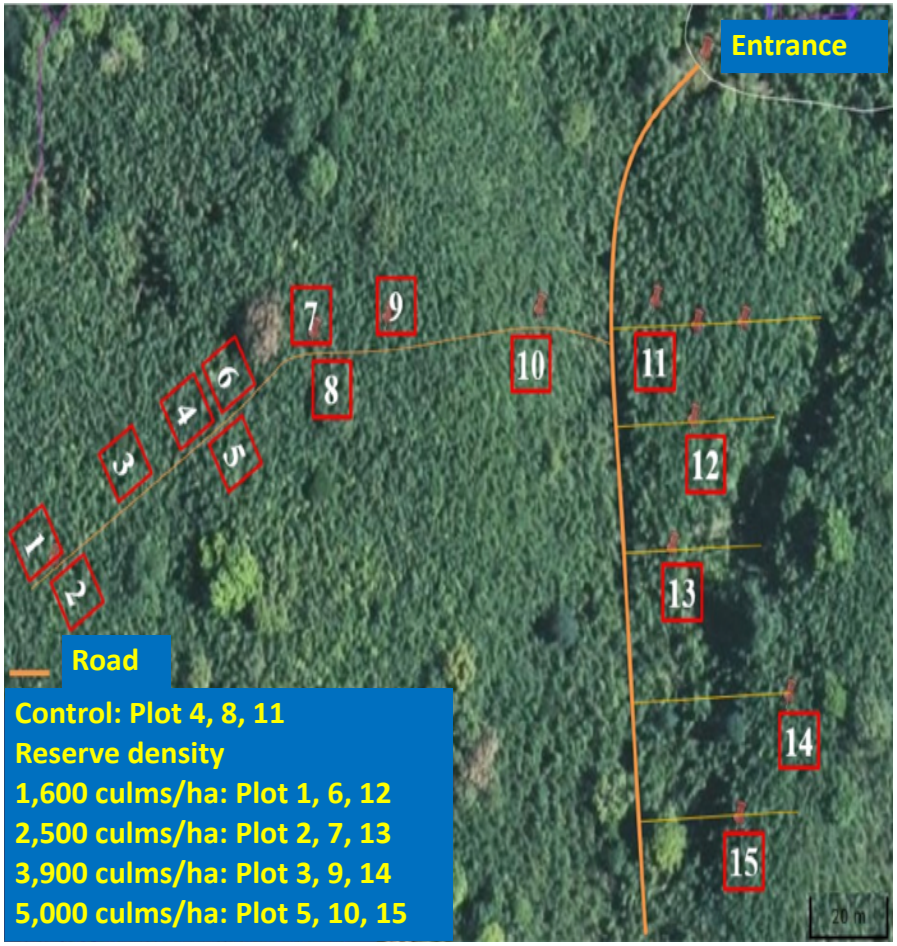
Site description



- research sites located in Dasi Working Circle Compartment 167 in Taoyuang City (E121 35' 19", N24 78' 72")
- with the elevation about 680 m above sea level.
- annually average temperature is 20℃, with the highest in July (25.6℃) and lowest in February (13.2℃).
- average annual precipitation was 2,954 mm, focused on June to September.

Experimental design

- 15 plots with 10*10m each were established for the monitoring
- Five reserved stand density (1,600 culms ha^{-1}, 2500 culms ha^{-1}, 3,900 ha^{-1}, 5000 culms ha^{-1},and control) were carried out in the thinning operation.
- Each treatment with three duplicates was randomly assigned in the field
- Thinning practice was carried on the March 2019.
- The survey of new culms growth was carried in April, June and August 2019, respectively.
- The survey of new culms growth were continuously carried on the bamboo growing season for 2020, 2021, and 2022.



Results and Discussions

- Before thinning in the age composition, culms were dominated by age over 4 years (52.7%), only 3.4% culms in age 1 year were found, indicating the serious unbalanced in age distribution, because of no management over 20 years
- Moreover, because of many dead and fallen culms in the stands, and some of them was attacked by Witche's broom, and even in flowering, thus, the bamboo stand was regarded as in unhealthy

Culms growth in age before thinning

- The comparison of culms growth among age showed that the growth of 1-year culms was the worst in the average DBH (2.5±0.7 cm) and height (7.2±2.1 m) among age classes.
- However, for culms in age 4-year and over, their growth was the best in the average DBH (5.4±0.8 cm) and height (14.0±2.8 m) (Table 2).
- This significant difference in culms growth among age indicated that stand was in upper story by culms age 4-year and over. Culms in age 1-year were suppressed, therefore, only a slight growth was attained in the stands.

Table 2 Average growth in culms among age classed in Compartment 167 before thinning (March 2019)

Age	DBH (cm)	Height (m)
1-year	2.5±0.7$^{a1)}$	7.2±2.1^{a}
2-year	3.8±1.0^{b}	9.7±2.9^{b}
3-year	4.3±0.8^{c}	11.8±2.8^{c}
4-year & over	5.4±0.8^{d}	14.0±2.8^{d}

1) mean ± stand deviation. The same character means no significant difference under α=0.05 in ANOVA test.

The number of new culms occurred among months in 2019

Table 3 Growth of new culms in Compartment 167 in 2019

Reserve density	Time for survey	Average DBH (cm)	Average Height (m)	New culms emergence	Dead culms	Total new culms (10X10 m)
1,600 culms ha^{-1}	April	3.6±0.2$^{a1)}$	5.0±0.4^{a}	70±11	0	70±11^{abc}
	June	3.4±0.2^{a}	7.0±0.3^{cd}	13±4	0	83±12^{bcd}
	August	3.3±0.2^{a}	8.3±0.6^{de}	1±1	1±1	83±10^{bcd}
2,500 Culms ha^{-1}	April	3.5±0.5^{a}	5.0±0.7^{a}	66±4	0	66±4^{a}
	June	3.4±0.3^{a}	6.7±1.0^{bcd}	9±3	0	75±1^{abcd}
	August	3.4±0.3^{a}	8.0±1.3^{de}	3±3	2±3	75±6^{abcd}
3,900 culms ha^{-1}	April	3.6±0.3^{a}	5.2±0.2^{ab}	68±10	0	68±10^{ab}
	June	3.4±0.3^{a}	7.1±0.5^{cd}	15±12	0	83±2^{bcd}
	August	3.3±0.4^{a}	7.9±0.6^{de}	5±4	0	88±3^{d}
5,000 culms ha^{-1}	April	3.4±0.5^{a}	5.2±0.7^{ab}	74±8	0	74±8^{abcd}
	July	3.3±0.4^{a}	7.2±1.3^{d}	9±2	0	83±9^{bcd}
	August	3.3±0.4^{a}	8.1±1.4^{de}	3±2	1±1	85±9^{cd}
control	April	4.6±0.6^{b}	5.6±0.6^{abc}	59±9	0	59±9^{a}
	June	4.5±0.6^{b}	9.2±1.3^{ef}	6±1	0	65±9^{a}
	August	4.5±0.6^{b}	10.1±0.8^{f}	0	0	65±9^{a}

1) mean ± stand deviation. The same character means no significant difference underα=0.05 in ANOVA test.

- The survey of new culms growth in 2019 showed that for all treatments, the new culms occurred in April is most in number with the notable decrease in amount in June. Almost no culms occurred in the August, because of no bamboo shoots emergence since that time (Table 3).

Total number of new culms among treatments in 2019

No significant difference in the total number of new culms was detected for reserved density from 1,600 ha^{-1} to 5,000 ha^{-1} in 2019. However, the amount of total new culms for the four treatments (75-88 culms) are higher than that occurred in the control (65 culms) indicating that that thinning practice is beneficial to the generation of bamboo new culms.

Size of new culms compared among months in 2019 (1)

While the size for new culms in April, June and August in treated plots (DBH 3.3-3.6 cm) were smaller than the average culms size (DBH 4.7 cm) before thinning, however, compared to 1-year culms size before thinning (DBH 2.5 cm), It is much better in growth in the treated plots.

Size of new culms compared among months in 2019 (2)

- This study showed that the culms emerged on April, no matter thinned or not, were greatest in size (DBH 3.4-4.6 cm), followed by culms on May and June (DBH 2.1-3.2 cm) and culms on July and August (DBH 1.2-2.3 cm) in 2019.
- Since the bamboo shoots started from March, the early sprouted bamboo shoots getting more nutrients from rhizome, consequently, the size of culms is largest, however, with the decrease nutrients in rhizome , the culms appeared in later is more slender in size (Table 4).

Table 4. Comparison of new culms size occurred in different months in 2019

Reserved density	Occurred month	Average DBH (cm)
1,600 culms ha^{-1}	April	3.6±0.2
	May-June	2.1±0.1
	July-August	2.3
2,500 culms ha^{-1}	April	3.5±0.5
	May-June	2.2±0.6
	July-August	1.4±0.4
3,900 culms ha^{-1}	April	3.6±0.3
	May-June	2.3±0.2
	July-August	1.2±0.4
5,000 culms ha^{-1}	April	3.4±0.5
	May-June	2.3±0.6
	July-August	1.5±0.4
control	April	4.6±0.6
	May-June	3.2±0.6
	July-August	1.9

The recovery of bamboo stand density in 5 months later (August 2019)

Plot	Reserved culms in (10X10 m)	Number of new culms (10X10m)	Mortality of new culms (10X10m)	Mortality of reserved culms (10X10m)	Total culms (reserved and new culms (10X10m)	Average culms (ha^{-1})
1	16	88	1	0	103	9,900±1,000
6	16	71	0	0	87	
12	16	91	1	0	106	
2	25	82	2	0	105	9,900±800
7	25	77	0	0	102	
13	25	76	8	3	90	
3	39	85	0	0	124	12,700±300
9	39	90	0	0	129	
14	39	89	0	0	128	
5	50	81	0	0	131	13,500±900
10	50	98	2	0	146	
15	50	80	1	0	129	
4	171	59	0	1	229	22,000±1100
8	166	63	1	20	208	
11	151	75	0	3	223	

- The culms density before thinning practice is 17,400 culms/ha.
- Regarding the recovery of bamboo stand density in five months later in August 2019 after thinning , for the reserved density 1,600 culms/ha and 2,500 culms/ha stands, the average culms recover back to 9,900 culms/ha, for the reserved culms 3,900 culms/ha and 5,000 culms/ha, the culms go back to 13,000 culms/ha.
- Base on the previous studies , the stand culms keeping 12,500 culms/ha is an appropriate density for the makinoi bamboo management, therefore, in our case, the reserved culms should be kept 3,900 culms/ha or 5,000 culms/ha.
- For the control plots , the average of culms becomes 22,000 culms/ha.

New growth, dead and stand density changing in 2019-2022(10X10m)

Reserved density	Plot	New clums				Dead clums				Stand density				Original density
		2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022	2018
1,600 culms ha^{-1}	1	88	53	20	38	3	12	15	29	101	142	147	156	130
	6	71	45	13	20	0	10	13	15	87	122	122	127	162
	12	91	37	19	32	3	19	18	22	106	124	125	135	154
Average		83.3	45.0	17.3	30.0	2.0	13.7	15.3	22.0	98.0	129.3	131.3	139.3	148.7
2,500 culms ha^{-1}	2	82	58	15	40	3	10	9	19	104	152	158	179	145
	7	77	43	2	10	2	4	13	12	100	139	128	126	160
	13	76	40	16	31	17	20	17	17	84	104	103	117	151
Average		78.3	47.0	11.0	27.0	7.3	11.3	13.0	16.0	96.0	131.7	129.7	140.7	152.0
3,900 culms ha^{-1}	3	85	47	5	46	2	11	8	14	122	158	155	187	154
	9	90	95	9	57	2	6	9	20	127	216	216	253	231
	14	90	59	13	25	2	14	11	27	127	172	174	172	220
Average		88.3	67.0	9.0	42.7	2.0	10.3	9.3	20.3	125.3	182.0	181.7	204.0	201.7
5,000 culms ha^{-1}	5	81	60	13	30	0	7	4	27	131	184	193	196	188
	10	98	72	7	53	5	4	7	17	146	214	214	250	224
	15	81	49	9	22	5	12	15	18	127	164	158	162	204
Average		86.7	60.3	9.7	35.0	3.3	7.7	8.7	20.7	134.7	187.3	188.3	202.7	205.3
control	4	59	4	12	28	23	30	26	33	207	181	167	162	171
	8	63	44	9	37	27	23	18	29	202	223	214	222	167
	11	75	44	7	21	27	40	16	25	199	203	194	190	151
Average		65.7	30.7	9.3	28.7	25.7	31.0	20.0	29.0	202.7	202.3	191.7	191.3	163.0

The continuous four years monitoring data after thinning in 2019, stand densities increased no matter what reserved density was proceeded, but control plots decreased (202 to 191) slightly.

Stand densities of 3,900 & 5,000 culms ha-1 were exceeded the original densities in 2020-2022.

DBH of new culms growing in 2020-2022

The average DBH of new culms grew larger starting from the 2nd year after thinning.

These results would be recommended the next cycle of thinning after 3 years later.

Reserved density	Plot	Average DBH of new clums (cm)			
		2019	2020	2021	2022
1,600 culms ha^{-1}	1	3.4 ±0.9	4.0 ±1.1	4.3 ±1.1	5.2 ±1.2
	6	3.5 ±1.1	4.2 ±1.1	5.1 ±0.8	5.5 ±0.6
	12	3.3 ±1.1	4.3 ±1.1	4.4 ±0.7	4.3 ±1.1
Average		3.4 ±1.0	4.1 ±1.1	4.6 ±0.9	5.0 ±1.0
2,500 culms ha^{-1}	2	3.2 ±1.1	3.9± 1.1	4.8 ±0.7	5.2 ±0.7
	7	3.7 ±1.1	4.4 ±1.1	5.2 ±0.2	5.2 ±0.9
	13	3.0 ±1.1	4.0 ±1.0	4.5 ±0.9	4.5 ±0.9
Average		3.3 ±1.1	4.1 ±1.1	4.8 ± 0.6	4.9 ±0.8
3,900 culms ha^{-1}	3	3.7 ±1.2	4.0 ±1.0	4.5± 0.9	5.1 ±0.8
	9	3.1 ±1.0	3.2 ±0.8	4.4 ±0.7	4.3 ±0.7
	14	3.1 ±1.0	4.2 ±1.0	5.0 ±1.0	4.5 ±1.0
Average		3.3 ±1.1	3.8 ±0.9	4.6 ±0.8	4.6 ±0.8
5,000 culms ha^{-1}	5	3.6 ±1.2	3.9 ±1.0	4.9 ±1.0	5.1 ±0.8
	10	2.8 ±0.9	3.5 ±0.9	3.9 ±0.5	4.3 ±0.9
	15	3.4 ±1.0	4.1 ±1.1	4.7 ±1.0	4.4 ±0.8
Average		3.3 ±1.0	3.8 ±1.0	4.5 ±0.8	4.6 ±0.9
control	4	5.2 ±0.9	4.0 ±1.4	5.0 ±1.2	5.2 ±1.1
	8	4.2 ±1.1	3.9 ±1.0	4.6 ±0.5	5.3 ±0.9
	11	4.0 ±0.8	4.2 ±0.8	3.8 ±1.0	3.5 ±1.2
Average		4.5 ±0.9	4.0 ±1.1	4.5 ±0.9	4.7 ±1.1

cut dead and fallen culms in control plots

- While no thinning practice was carried on the control plots, we still cut the dead and fall culms on the control plots. The new culms were 59-75 culms (10X10 m), which is apparently higher than that in 1-yr culms before thinning (0-4 culms).
- This demonstrated that only cut dead and fallen culms is helpful for the new culms growth as well because of more space and lights in the stand.

CONCULSIONS

This study showed in the case of reservation density in 1,600 to 5,000 clums ha^{-1}, there was no significant difference among one another in growth for the total number of new culms.

If 12,500 culms ha^{-1} was considered as the optimal density, for the long time abolished bamboo stands in Compartment 167 in Dasi Working Circle, the optimal reservation density should be 3,900 culms ha^{-1} or 5,000 culms ha^{-1} in the operation in 2019.

The cycle of thinning in makino bamboo forest

- The four-year data(2019-2022) in the increased stand density over the original densities and DBH of new culms grew larger after thinning showing in this study indicated that the makino bamboo forest should be thinned in cycles of 4 years with reserved 3,900 culms ha^{-1} or 5,000 culms ha^{-1} in the thinning practice for the sustainable bamboo management and utilization.

Answers to questions asked in this research

1. *Does it need to do thinning operation for the abolished makino bamboo forest ?*

   → **YES**

2. *What is the optimal level for the residual stand density after thinning ?*

   → **The optimal reservation density should be 3,900 or 5,000 culms ha^{-1} after thinning**

3. *What is the years of thinning cycle for the sustainable bamboo management and utilization ?*

   → **In cycles of 4 years**


Thanks for
Your
Attention