Extension Note

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Ecological descriptions of Pacific golden chanterelle (*Cantharellus formosus*) habitat and estimates of its extent in Haida Gwaii

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Abstract

Ecologically based information on golden chanterelle (*Cantharellus formosus*) habitat is needed to guide decision making by forest managers. We described soils, plant communities, and stand characteristics of productive mushroom sites and used these features in a mapping exercise to estimate the extent of *C. formosus* habitat over a portion of the Haida Gwaii islands. Chanterelle sites were located at low elevations (approximately 100 m) on well-drained soils with silt loam to sandy loam textures and thin forest floors. Plant communities were sparse and characterized by low herb and shrub cover with extensive carpets of feathermosses. The stands were productive second-growth western hemlock and Sitka spruce, ranging in age from 35 to 50 years, and the sites were strongly mounded from extensive blowdown events or logging disturbances. The site and soil properties were consistent with the zonal (01) site series (western hemlock – Sitka spruce – lanky moss) of the submontane variant of the wet hypermaritime Coastal Western Hemlock (CWHwh1) subzone. A preliminary assessment of *C. formosus* habitat around Skidegate Lake indicated approximately 1785 ha of mesic forests (equal to 21% of the assessed forest area) with a major portion covered by immature stands conducive to commercial picking. This information on the nature and extent of *C. formosus* habitat provides the first step in successful co-management of timber and mushroom resources.

KEYWORDS: *biogeoclimatic ecosystem classification,* Cantharellus formosus*, commercial mushroom harvest, non-timber forest products.*

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Introduction

The Pacific golden chanterelle (*Cantharellus formosus* Corner) is a valuable non-timber forest product in Haida Gwaii (Queen Charlotte Islands), British Columbia, providing seasonal employment and economic benefits for both local residents and visiting mushroom pickers. An annual harvest ranging from 45 000 to 115 000 kg, with up to 300 pickers participating, occurs from August to October in select productive forests of the islands (Tedder et al. 2000). The island community formally expressed a desire to sustain the harvesting of mushrooms through integrated land use plans (Haida Gwaii/Queen Charlotte Island Land Use Plan 2006).

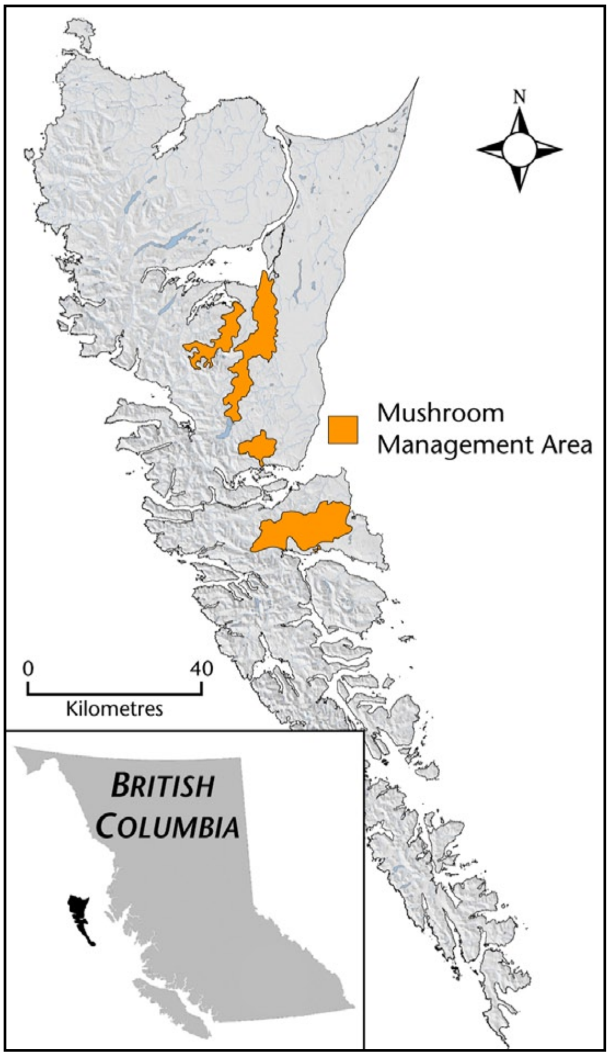

FIGURE 1. Mushroom management areas identified for Haida Gwaii (Source: Haida Gwaii/Queen Charlotte Island Land Use Plan 2006).

Although approximate areas of commercial chanterelle harvesting on Haida Gwaii are known, more ecologically based information on chanterelle habitat is needed to guide decision making by forest managers.

Approximate areas of commercial chanterelle harvesting on Haida Gwaii are known (Figure 1), but more ecologically based information on chanterelle habitat is needed to guide decision making by forest managers.

Cantharellus formosus is an ectomycorrhizal fungal species on a number of host tree species including Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and Sitka spruce (*Picea sitchensis*) (Pilz et al. 2003). *C. formosus* is generally found in low-elevation coastal forests throughout the Pacific Northwest, ranging from California to Alaska, but the more productive habitat is typically second-growth coniferous stands that were clearcut (Dunham et al. 2006). Microsite variables associated with *C. formosus* include relatively thin forest floors, low exchangeable acidity, and low levels of moss cover (Bergemann and Largent 2000), and possibly well-rotted coarse woody debris (Pilz et al. 2003). In British Columbia, the habitat of *C. formosus* has been described on Vancouver Island using the biogeoclimatic system of classification (Pojar et al. 1987). These sites are located in the Coastal Western Hemlock (CWH) zone with the majority of habitat on medium-textured soils that have moderate productivity and a low cover of herbs and shrubs with widespread feathermosses (Ehlers 2003).

The objective of this note was to contribute further ecological descriptions of *C. formosus* habitat from the more northern extent of its range in the Pacific Northwest. We described soils, plant communities, and stand characteristics of productive mushroom sites within Haida Gwaii, and examined whether *C. formosus* habitat was consistent and specific enough across these forests to potentially map commercial mushroom harvesting areas as has been successfully done with pine mushrooms (*Tricholoma magnivelare*) (Kranabetter et al. 2002). Estimates of the extent of *C. formosus* habitat were made from air photographs covering an 8500-ha study area, and this preliminary survey will help inform forest managers and the interested public on the opportunities and challenges in managing both timber resources and commercial mushroom harvests.

Materials and methods

Site selection

In September 2007, three experienced mushroom pickers based in Haida Gwaii accompanied us to sites known to be highly productive golden chanterelle habitat. Chanterelles were found in each plot to confirm habitat suitability, and locations were selected within as wide a range of landforms and site characteristics as possible. These plots were located in an area just north of Queen Charlotte City, in areas along the north and south sides of Skidegate Lake, and in areas closer to Mosquito Lake and Gray Bay.

Ecosystem descriptions

We undertook full ecological descriptions and biogeoclimatic (BEC) site classification for nine plots. Standard procedures, as described in "Field Manual for Describing Terrestrial Ecosystems" (BC Ministry of Environment and BC Ministry of Forests 1998) were used to describe site characteristics, vegetation, and soils for each plot. All plant species were listed by stratum with estimates of their percent cover. The combined percent cover for each stratum was also recorded. Plant names corresponded to those used by Pojar and MacKinnon (1994) in *Plants of Coastal British Columbia*. Soil pits were excavated to a depth of at least 50 cm (Figure 2), and descriptions of the humus form and mineral soil profiles were recorded.

Moisture regime was ranked from 0 (very dry) to 7 (wet) and nutrient regime from A (very poor) to E (very rich), with the corresponding site series identified using "A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region" (Green and Klinka 1994). Landforms, soil pedons, and humus forms were classified according to the "Terrain Classification System for British Columbia" (Howes and Kenk 1997), The "Canadian System of Soil Classification" (Soil Classification Working Group 1998), and "Towards a Taxonomic Classification of Humus Forms" (Green et al. 1993), respectively.

Stand characteristics

Forest cruise plots were done at each site to determine stand characteristics (BC Ministry of Forests 2000). A full prism sweep was made at plot centre, and the diameter at breast height (DBH) was noted for each "in" tree. One or two co-dominant trees of hybrid Sitka

FIGURE 2. Typical soil pit from productive mushroom sites in Haida Gwaii.

spruce and western hemlock were cored at breast height (1.3 m) for age, and tree heights were measured using a Vertex Forester. Site indices were calculated based on tree age and height using BC Ministry of Forests Site Tool (version 3.2B).

Air photograph interpretation

A pilot area encompassing 8450 ha was chosen for a mapping exercise to estimate the extent of productive chanterelle habitat. Photo signatures for the classified 01 site series were referenced from colour air photographs taken along the northern portion (Photos 15BCC04002: 98–103; scale 1:25 000) and southern portions (Photos MB94003: 162–169; scale 1:15 000) of Skidegate Lake. The photo signature for CWHwh1/01 ecosystems was based on the nine full ecological plots along with a further five mesic stands also confirmed as mushroom sites in the area. Both landscape position and crown characteristics were used to identify the appropriate habitat (minimum 90% coverage of 01 site series within a mapped polygon).

The mesic site series of the submontane variant of the wet hypermaritime Coastal Western Hemlock subzone (CWHwh1/01) occurred on convex-shaped landforms with the moderately high productivity of the stands distinguished by the slightly smaller tree crowns occurring close together and appearing as a deep green, uniform texture on the air photograph. The majority of the landscape was covered with immature forests, but we also examined older forests for a more complete inventory of potential habitat. More recently logged areas (less than 20 years) were not mapped because of the difficulties in assessing site quality. The mapped polygons were digitized to determine polygon size and the relative percent of CWHwh1/01 sites over the pilot area (excluding lakes and other non-productive areas).

Results

Site and soils

All chanterelle sites were at low elevations (70–110 m) within the wet hypermaritime subzone, submontane variant of the Coastal Western Hemlock zone (CWHwh1) (Table 1). Landforms were morainal veneers or blankets over bedrock, derived primarily from sedimentary (likely shale) parent materials, with plots predominately at mid- to upper-slope positions with variable aspects. Mineral soils were medium textured (predominantly sandy loam to silt loam) and judged to be well drained because of low clay content. Coarse fragment content was low, and rooting depth reached approximately 50 cm (Figure 2). Forest floors were thin, averaging 3 cm, usually with a matted structure and tenacious consistency (designated as an Fm horizon). Soils were classified as either Orthic Humo-Ferric Podzols or Ferro-Humic Podzols with Hemimor humus forms. All stands were logged and likely had widespread soil disturbance, and, in some cases, sites were burned as well. The sites were typically strongly mounded from extensive blowdown events, and soil horizons were well mixed and occasionally inverted. The site and soil properties corresponded to a fairly narrow range of moisture (ranked "fresh" or 3+ to 4) and nutrient regimes (ranked "medium" or C to C+), all equivalent to mesic ecosystems (Table 1).

Vegetation and stands

Tree cover (Layer A) of chanterelle habitat was exclusively western hemlock and Sitka spruce, at generally even proportions, with western redcedar being notably absent except occasionally in the shrub layer (Table 2). Western hemlock was the most abundant understorey species in the B layer, and other shrub species such as *Vaccinium parvifolium*, *V. ovalifolium*, *Rubus spectabilis*, and *Gaultheria shallon* contributed usually less than 5% cover. The herb layer (Layer C) was also low, often less than 5%, and included small amounts of *Polystichum*

TABLE 1. Site and soil attributes for productive *C. formosus* sites on Haida Gwaii.

	Plot no.								
Site-soil properties	**9128**	**9129**	**9130**	**9131**	**9132**	**9133**	**9134**	**9135**	**9136**
SITE									
Elevation (m)	71	110	na	109	91	90	95	93	93
Slope (%)	3	3	35	12	14	55	15	35	25
Aspect (degrees)	270	260	30	180	180	250	230	180	10
Mesoslope position[a]	LV	UP	MD	UP	UP	MD	UP	MD	MD
FOREST FLOOR									
Depth (cm)	3	4	4	3.5	6	4	2	2.5	1
Classification[b]	HR	RR	RR	HR	HR	HR	HR	HR	HR
MINERAL SOIL									
Dominant soil texture[c]	L	L	fSL	SiL	SL	SiL	SL	SiL	SiL
Drainage class[d]	W	W	W	W	W	W	W	W	W
Coarse fragment (%)	5	10	20	5	15	10	5	15	25
Rooting depth (cm)	60	30	55	55	40	30	50	50	40
Classification[e]	O.HFP	O.HFP	O.FHP	O.FHP	O.HFP	O.HFP	O.HFP	O.HFP	O.HFP
Moisture/nutrient regime	4 C+	4 C	4 C+	4- C+	4- C	4 C+	3+ C	3+ C	4 C

[a] LV = level, UP = upper, MD = middle
[b] HR = hemimor, RR = resimor
[c] L = loam, fSL = fine sandy loam, SL = sandy loam, SiL = silt loam
[d] W = well drained
[e] O.HFP = orthic humoferric podzol, O.FHP = orthic ferrohumic podzol

TABLE 2. Plant species and percent cover for productive *C. formosus* sites on Haida Gwaii.

	Plot no.									
Species by canopy layer	**9128**	**9129**	**9130**	**9131**	**9132**	**9133**	**9134**	**9135**	**9136**	**Average**
COVER FOR LAYER A (%)	**80**	**75**	**65**	**65**	**80**	**75**	**75**	**60**	**70**	**71.7**
Picea sitchensis	20	35	30	40	40	40	30	50	45	36.7
Tsuga heterophylla	70	40	40	30	35	40	50	30	30	40.6
COVER FOR LAYER B (%)	**16**	**6**	**12**	**14**	**16**	**6**	**20**	**16**	**25**	**14.6**
Gaultheria shallon							1	1	2	0.4
Menziesia ferruginea			0.1	0.5						0.1
Rubus spectabilis		0.5	3	2	1					0.7
Thuja plicata	2		2		1		2			0.8
Tsuga heterophylla	15	4	3	8	10	5	15	15	20	10.6
Vaccinium ovalifolium		1		0.5						0.2
Vaccinium parvifolium	1	1	2	3	5	1	2	0.5	3	2.1
COVER FOR LAYER C (%)	**1**	**2.5**	**3**	**7**	**6**	**6**	**3**	**4**	**8**	**4.5**
Blechnum spicant	0.5	1	1	2	2		0.5	0.5	3	1.2
Dryopteris assimilis	0.01	0.1	1	1	0.5	0.1				0.3
Galium triflorum								0.1		0.0
Gymnocarpium dryopteris		0.5		0.1		0.1				0.1
Listera cordata				0.1			0.1		0.1	0.0
Lycopodium clavatum			0.1	0.1	0.5		2	2		0.5
Maianthemum dilatatum		0.1			0.1		0.5	0.5	0.5	0.2
Melica subulata				0.1			0.5			0.1
Moneses uniflora			0.1	0.1	1	1		0.1		0.3
Polystichum munitum	1	1	1	4	2	5		1	5	2.2
COVER FOR LAYER D (%)	**60**	**45**	**60**	**95**	**85**	**70**	**95**	**96**	**95**	**77.9**
Atrichum selwynii	1	0.1	2	1	0.5	8			1	1.4
Barbilophozia lycopodiodes	0.5					0.1		0.1		0.1
Dicranum scoparium								1		0.1
Hylocomium splendens	10	3	5	50	30	5	20	15	55	15.9
Hypnum circinale		0.1								0.0
Kindbergia oregana		3	3	3	10	15	40	75	10	17.3
Peltigera neopolydactyla					0.1		1	0.5	2	0.4
Plagiochila porelloides	1									0.1
Plagiothecium undulatum	20	10	10	5	2	10		1	3	6.2
Pseudotaxiphyllum elegans	0.1									0.0
Rhizomnium glabrescens	20	30	30	5	5	12	3	5	4	12.1
Rhytidiadelphus loreus	10	5	20	25	40	30	30	5	20	17.8
Scapania bolanderi		0.5				0.1				0.1
Sphagnum girgensohnii		1					1		2	0.4

munitum, *Blechnum spicant*, *Melica subulata*, *Moneses uniflora*, *Listera cordata*, and *Gymnocarpium dryopteris*. The vegetation cover was undoubtedly modified to some degree, however, by extensive deer browsing found throughout the islands. Mosses in the D layer typically carpeted the forest floor, and the dominant species included *Hylocomium splendens*, *Rhytidiadelphus loreus*, and *Kindbergia oregana*. The low shrub and herb cover with extensive moss layers is consistent with the described site and soil properties (Figure 3) and would be classified as the zonal (01) site series (western hemlock – Sitka spruce – lanky moss) (Green and Klinka 1994).

The stands were all second-growth forests ranging in age from 35 to 50 years (Table 3) and likely naturally regenerated after clearcut harvesting (plot 9132 was not aged because of equipment malfunction). Stand basal area at these ages was approximately 56 m^2/ha with trees 28 m in height and 35 cm in diameter, on average. A few of these stands had been thinned in the previous decade, and all stands were relatively well spaced, healthy, and productive. Site index (height at age 50) ranged from 30 to 35 m for both Sitka spruce and western hemlock with the exception of one less productive site (plot 9136). These indices were comparable to other sites characterized by fresh moisture regimes and medium nutrient availability in the CWHwh1 (Kayahara and Pearson 1996).

FIGURE 3. Typical stand and vegetation community for productive mushroom sites in Haida Gwaii.

Habitat mapping

A total of 231 polygons were mapped as CWHwh1/01 ecosystems within the project area surrounding Skidegate Lake. Some of these stands were adjoined but labelled as separate polygons because of significant differences in aspect or stand age. We combined the adjoined polygons for the purposes of the mapping summary, which reduced the number of total polygons to 181. The largest individual stand was 79 ha, and the more closely grouped polygons encompassed up to 110 ha. The lower size limit of polygons was 1 ha, and the average polygon size was 9.9 ha. The sum total of the mapped 01 stands was 1785 ha, which was equal to 21% of the forested landscape (note that a small portion of the project area, approximately 250 ha, had very young stands that could not be assessed). The

TABLE 3. Forest stand attributes for productive *C. formosus* sites on Haida Gwaii.

	Plot no.								
Stand attributes	**9128**	**9129**	**9130**	**9131**	**9132**	**9133**	**9134**	**9135**	**9136**
Basal area (m^2/ha)	56	77	70	56	70	56	49	35	35
Age (years at DBH)	38	36	35	49	–	41	52	50	52
AVERGE HEIGHT (m)									
Spruce	23	25.5	26.5	34	21.5	31.5	31	31	24
Western hemlock	23	26.5	25	28	23	27.5	30	21	17
AVERAGE DIAMETER (cm)									
Spruce	21	33	37	51	27	38	48	43	30
Western hemlock	24	35	32	36	31	44	36	34	17
SITE INDEX (m @ 50 yr)									
Spruce	31	35	34	34	–	35	31	30	24
Western hemlock	30	35	35	32	–	31	32	23	19

majority of the 01 habitat was second-growth stands, but the exact extent is unknown because forest cover information is not publically available under the forest tenure covering this portion of Haida Gwaii.

Discussion

The descriptions of *C. formosus* habitat from Haida Gwaii were comparable with sites from Vancouver Island (Ehlers 2003) and were consistently located on low elevation, moss-dominated mesic ecosystems (CWHwh1/01 – lanky moss) with immature stands of Sitka spruce and western hemlock. Microsites with thin forest floors were consistent with productive habitat but not low moss cover (Bergemann and Largent 2000), and, as Dunham et al. (2006) also noted, the association of *C. formosus* with buried wood was not apparent from these study sites. Mesic ecosystems are generally extensive in these landscapes, which, along with large-scale logging operations in the 1950s and 1960s, have led to the widespread and abundant fruiting of *C. formosus*. We also noted large numbers of *Boletus edulis* (King bolete) and the occasional *Polyozellus multiplex* (blue chanterelle) in this same forest habitat, which could support additional mushroom harvests from these stands (Tedder et al. 2000). The results of the study would suggest there are opportunities for the co-management of timber and mushroom resources but also potential conflicts depending on the rotation age of the second-growth stands.

For most attributes, the chanterelle sites fit the CWHwh1/01 concept well, but using herb and shrub indicator species to assess soil nutrient regimes can be problematic under second-growth stands, especially with extensive deer browse (Kayahara and Pearson 1996). For example, the rich-indicator species sword fern (*Polystichum munitum*) was sometimes noted on steeper slopes and on chanterelle sites with very thin humus layers, suggesting perhaps a better than average soil nutrient regime (also noted by Ehlers [2003]). A few plots also had quite high cover of the moss *Kindbergia oregana*, which, based on its distribution in other coastal forest ecosystems, would also indicate slightly richer soils. It is possible that the cover of *K. oregana* and *P. munitum* were temporarily elevated in second-growth stands due to the scalping of forest floors during past logging events, and that over time these species could decline as forest floor depth increases under climax stands. However, in hypermaritime climates, we also expect some beneficial effects of soil disturbance on site productivity when deep mixing of the profile counteracts the strong weathering and podzolization processes that limit phosphorus and cation availability (Kranabetter et al. 2005a). It might, therefore, be acceptable to classify some of these chanterelle sites as transitional to CWHwh1/03 sword fern to reflect richer soil nutrient regimes.

We walked through a few moist, rich sites (CWHwh1/05 and /06) and were unable to find any chanterelles, which would support the mapping of CWHwh1/01 sites as commercial habitat. Further investigations of more contrasting sites and landforms could help refine soil nutrient regimes, which were predominantly ranked medium (to perhaps slightly rich) but might also include poorer soils as described elsewhere in the Pacific Northwest (Pilz et al. 2003). At a microsite level, we often found large mushroom fruitings on the tops of hummocks or on the convex part of a slope, which would suggest that well-drained, moisture-shedding microsites (3 to 3+ moisture regime) were ideal. Therefore, within mesic polygons, separating out moderately well-drained soils or sites with few hummock features might eliminate less productive habitat. This degree of precision in ecosystem mapping was not possible with the air photographs provided, however, and would likely require either field assessments to more closely evaluate site features or air photographs of finer resolution.

None of the described sites were old forests, and the apparent skewed distribution in fruiting to favour immature stands is consistent with other areas in the Pacific Northwest (Ehlers 2003; Dunham et al. 2006). The reduction in fruiting bodies with stand age suggests *C. formosus* is an early-seral species that is displaced to some degree by mid-seral and late-seral ectomycorrhizal fungal species during succession (Kranabetter et al. 2005b; Twieg et al. 2007). As an early-seral species, *C. formosus* would disperse and establish readily after forest harvesting; in fact, some evidence suggests soil disturbances such as broadcast burning further enhances *C. formosus* abundance in young stands (Peterson et al. 2000), perhaps due to the exclusion of other competing early-seral ectomycorrhizal species.

An important issue for forest managers and mushroom pickers is whether declines in fruiting with stand age would eventually render a site noncommercial for *C. formosus* harvests. Research under way on Vancouver Island suggests mushroom harvests could continue well past the anticipated rotation age of 70 years for these stands (T. Ehlers and R. Winder, pers. comm.). However, harvesting second-growth stands during the prime producing years of *C. formosus* could create an immediate conflict between timber and mushroom resources, whereas maintaining some immature stand age classes through time would be in the best interests of mushroom pickers. The mapping exercise demonstrated relatively extensive areas of potential mushroom habitat (21%), comparable in size to select areas with high concentrations of pine mushroom habitat in other parts of the province (Trowbridge 2005; Williams and Reid 2005), and so, perhaps, some land-use objectives could be agreed upon between industry and the public that would maintain a suitable proportion of productive sites. One advantage of the chanterelle habitat type is that individual stands are generally large enough (averaging 10 ha) to facilitate planning of harvesting schedules or leave areas. Commercial thinning of immature stands may also maintain chanterelle harvests while allowing some timber extraction (Pilz et al. 2006).

In conclusion, an inventory of mesic sites in the CWHwh1 approximated the potential commercial habitat for golden chanterelles, and immature second-growth stands within these sites were the best predictor of current commercial picking areas. To more fully understand the potential scope of the resource throughout the islands, further studies could be undertaken to examine the extent of *C. formosus* fruiting in other BEC variants (e.g., CWHwh2 at higher elevations) and stand age classes with the appropriate mesic habitat. General assessments of chanterelle habitat might be possible through existing terrestrial ecosystem maps (e.g., Lewis 2003) or, more approximately, through forest cover polygons, but we would recommend the interpretation and ground-truthing of ecosystems from air photographs for the most precise mapping of habitat. The preliminary assessment of *C. formosus* habitat around Skidegate Lake indicated that relatively large areas of commercial harvests are currently available, which should provide some flexibility in co-managing the land base for timber and mushroom resources.

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Harvesting second-growth stands during the prime producing years of C. formosus *could create an immediate conflict between timber and mushroom resources, whereas maintaining some immature stand age classes through time would be in the best interests of mushroom pickers.*

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Test Your Knowledge . . .

Ecological descriptions of Pacific golden chanterelle (Cantharellus formosus) *habitat and estimates of its extent in Haida Gwaii*

How well can you recall some of the main messages in the preceding Extension Note? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. Commercial picking of golden chanterelles on Haida Gwaii typically occurs in:
   A) High-elevation, productive forests of yellow-cedar and mountain hemlock
   B) Open, grassy meadows adjoining coastal beaches
   C) Low-elevation, moderately productive forests of western hemlock and Sitka spruce

2. The yields of golden chanterelles are typically best in:
   A) Old-growth forests with high amounts of coarse woody debris
   B) Second-growth stands of conifers at least 30 years in age
   C) Immediately postharvest on plantations that had been broadcast-burned

3. Golden chanterelles have these habitat attributes because this species is:
   A) An early-seral ectomycorrhizal fungi that colonizes the roots of conifers
   B) A saprophytic fungi utilizing decaying stumps in second-growth stands
   C) A pathogenic fungi that causes root rot in immature conifer trees

Answers

1. C 2. B 3. A